RTCA Special Committee 186, Working Group 5

ADS-B UAT MOPS

Meeting #6

Possible MOPS Appendix That Elaborates on Timing Requirements

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SUMMARY
This Working Paper presents a proposed Appendix to the UAT MOPS that provides rational for timing related requirements found in the UAT MOPS

Possible MOPS Appendix That Elaborates on Timing Requirements

The UAT MOPS establishes three separate requirements related to accuracy of timing that must be maintained by the UAT. This timing is necessary to support validation of position information reported in ADS-B messages by measuring propagation time of the ADS-B message from transmitter to receiver. Applications that perform this validation are however outside the scope of this MOPS and will be addressed elsewhere.

Requirement # 1: This may require an installed equipment test to confirm that the UAT was able to develop a 1 second UTC epoch signal (1 PPS) within the specified accuracy and stability. Figure X-1 below shows the individual components of timing uncertainty for a worst case UAT installations.

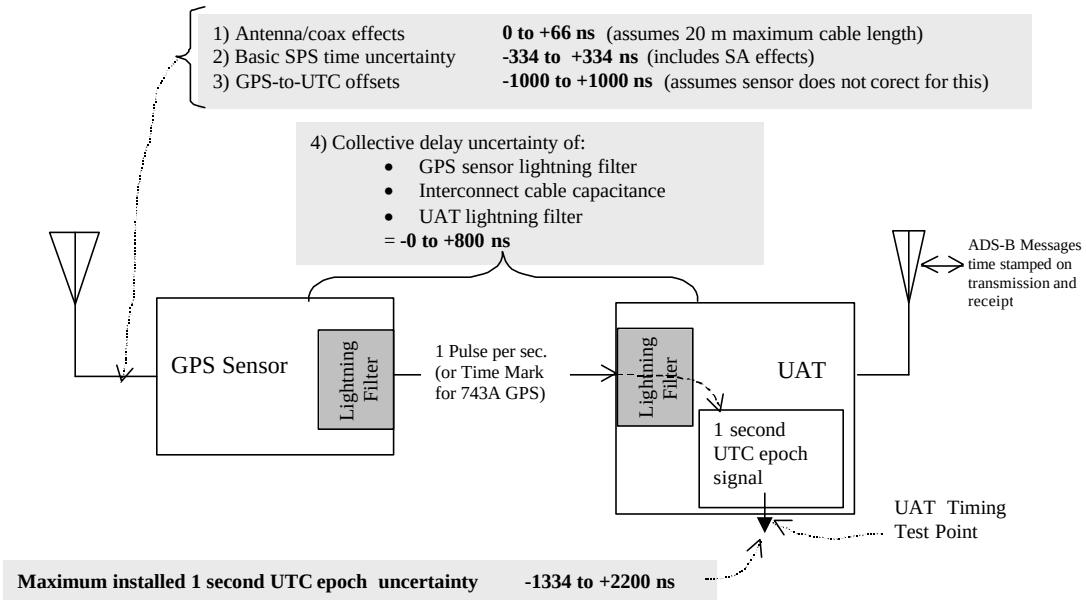

Figure X-1. An Accounting of Total Timing Uncertainty at UAT for Worst Case Installation

Notes on the figure:

a) Effect #3 (+/- 1000 ns) need not apply to an air carrier installation using an ARINC 743A sensor. The reason is that the ARINC 743A "Time Mark" pulse is referenced to UTC time through a "UTC Time of Time Mark" provided over the data bus. The block labeled "1 PPS UTC Generation circuitry" could use this to adjust the 1 second UTC epoch signal accordingly.

b) It is assumed that effects # 1 and 4 would be stable for any given installation, where the others would not be. However, we assume it will not be practical to require UAT installers to calibrate out these stable delays.

c) The uncertainty budget for effect #4 is based on testing performed by a GPS receiver manufacturer for general aviation installations using separate GPS sensor.

d) The UAT timing test point access is advantageous because its general; it applies no matter how the UAT manufacturer decided to get time. The following are all practical possibilities:

- Air carrier case where UAT couples to an ARINC 743A GPS. UAT takes in the "Time Mark" pulse and the "UTC Time of Time Mark" data word (and known internal lightening filter delay) and generates its own version of 1 PPS UTC.
- Decoupled (probably General Aviation) case where UAT interfaces with something like a TSO-C129 sensor with a only a 1 PPS output.
- Tightly coupled case where GPS sensor is part of UAT. In this case no *installed* test is required.

Requirement #2: This would be a test to determine how accurately the UAT transmits a message in time relative to when it should. This test would measure the actual time of RF message transmission relative to its 1 second UTC epoch signal and compare with the time that would be determined from the psuedo-randomly generated Message Start Opportunity (MSO) that was encoded in the message. We tentatively allow –320 to +320 ns tolerance on this with the assumption this could not be easily calibrated out by the UAT manufacturer.

Requirement #3: This would be a test to determine how accurately the UAT time stamps a received message. This test would compare the message time of arrival at the UAT antenna relative to its 1 second UTC epoch signal with that reported by UAT in the ADS-B Report output. We tentatively allow –320 to +320 ns tolerance on this with the assumption this could not be easily calibrated out by the UAT manufacturer.

Finally, the implications for air-air range measurements from all effects in combination (worst case) are as follows:

- Transmit side error relative to actual UTC: -1654 to +2520 ns
- Receive side error relative to actual UTC : -1654 to +2520 ns

End-end worst case (air-air) propagation time uncertainty: 4174 ns or ~0.68 nmi maximum range error.